



# FINAL REPORT

*(due within 3 months on completion of project)*

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## *Part 1 - Summary Details*

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Cotton CRC Project Number: 4.5.02

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**Project Title:** Standardisation of Classing

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**Project Commencement Date:** 01/07/2005    **Project Completion Date:** 31/06/2008

**Cotton CRC Program:**                      **The Product**

## *Part 2 – Contact Details*

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**Signature of Research Provider Representative:** \_\_\_\_\_

## ***Part 3 – Final Report Guide (due within 3 months on completion of project)***

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(The points below are to be used as a guideline when completing your final report.)

### ***Background***

1. Outline the background to the project.

There is consensus both locally and internationally that the measurement of cotton fibre properties by the traditional method of subjective classing should be replaced with the measurements by the relevant instruments in High Volume Instrument (HVI) lines. However, there are a number of technical and operational issues to overcome before objective measurement of these parameters is accepted with confidence by the cotton trade.

If Australia is to maintain its reputation as a consistent supplier of high quality cotton it needs to ensure that classing facilities in Australia consistently specify their cotton. To do this the cotton classing sector needs to be assessed independently, by the CSIRO's Textile and Fibre Technology, to determine; the reproducibility of the HVI lines installed; to conduct Round Trials that measure any differences between classing facilities in values of HVI colour and trash and to determine their compliance to the Best Management Practice (BMP) for Classing Handbook, compiled by the Cotton Classers Association of Australia (CCAA) via a formal audit. This will allow individual classing facilities to make technical and operational corrections to their practice, so that ultimately the industry can achieve consistent and better prediction of classing grades.

In 2005 the Australian classing sector consisted of nine classing facilities operating 26 HVI lines of different types, age and operating systems. It is thus understandable that a number of technical and operating issues need to be overcome before objective instrument measurement of fibre properties is accepted with confidence by the cotton trade. As a first step the Australian cotton industry proposed that the subjective classing of colour and trash, by using grade boxes from the USDA, be replaced by objective classing. In order to do this, rigorous Round Trials were conducted so that individual classing facilities could correct technical and operational shortcomings in their HVI practice so that the industry as a whole can work towards a better prediction of Australian classing grade by HVI measurement.

The main technical issues to be corrected included gaining agreement between the different colorimeters, cameras and scanners used in different HVI lines. The differences occur mainly because of different lighting sources and sensitivities by photo-detectors and colour filters used in the instruments. Furthermore, the algorithms used in HVI software to predict classing grade from the colour and trash measurements may be different between systems and not accurate for Australian cotton.

## *Objectives*

2. List the project objectives and the extent to which these have been achieved.

The objectives were to:

- Conduct formalised Round Trials to determine and measure the significance of any differences between classing facilities in values of HVI colour and trash. Due to the fact that the initial Round Trials showed that there were large differences in trash results (i.e. trash count, trash area and trash grade) it was decided, to exclude the measurement of trash as it is not repeatable enough.
- Conduct and analyse check test cottons on a weekly basis during the ginning season. A check test involves forwarding two samples of cotton weekly to the classing facilities in Australia for classing, both subjectively and objectively. The aim of the checktest is to determine the long term uniformity and reproducibility of each HVI line.
- Test and critically analyse the three Module Averaging methods being used in Australia and to make recommendations to the CCAA regarding the suitability of a single Module Averaging method.
- Conduct audits of commercial classing facilities to determine compliance to the current version of the Best Management Practice handbook for classing.

## *Methods*

3. Detail the methodology and justify the methodology used. Include any discoveries in methods that may benefit other related research.

### *1. Module Averaging*

Module Averaging was introduced in the US in 1991 as a means of improving the accuracy of instrument strength readings and to compensate for the natural variability of cotton. Under the USDA system every bale in a module is instrument tested and the results averaged on a module basis. The success of this initiative resulted in the expansion of Module Averaging in 1994 to include additional instrument measurements such as micronaire, length, and length uniformity. The classer assigned quality characteristics such as leaf grade and extraneous matter are not averaged, and each bale stands on its own for these characteristics.

Systems of module averaging have also been adopted in Australia since this time, ostensibly to provide information on bales that are not measured by HVI instruments. There were three module averaging systems in use in Australia. As part of the standardisation of classing program a statistical analysis of the three module averaging systems was conducted with the aim of highlighting the pros & cons of each system and to make a recommendation to industry on a single module averaging system to be adopted by the Australian cotton industry. The three systems work as follows:

- **System A** - Bale averaging; where every third bale is tested and the value is applied to the bales in between, which have not been tested. This system is currently being used by one classing facility.

- *System B* - Module averaging; where the average values of tested bales (every third bale) in a module is applied to bales that are not tested. This system is currently being used by six classing facilities.
- *System C* - Module averaging where every third bale is tested and the average value of the tested bales is applied to the module. This system is currently being used by one classing facility.

The analysis was conducted on a data set of 113 modules, comprising 2424 bales, covering a wide range of fibre properties. All the bales in the modules were 100% tested to enable a direct comparison with the three module averaging systems currently in use in Australia. The grand average, standard deviation, coefficient of variation and 95% confidence limits were calculated for each module averaging system.

## **2. Colour Round Trials**

In total six formalised Round Trials were conducted by the CCAA in 2004, 2006, 2007 and 2008 to identify and remedy any significant differences in colour results between classing facilities and HVI lines with the aim of moving to the determination of colour by objective measurement.

Samples for testing were prepared by the CCAA and cover a wide range of cotton quality and colour. These samples are forwarded and tested by each of the various classing facilities according to an agreed upon procedure which needed to be followed when testing the samples on the various operational HVI lines. Results from these trials were then forwarded to CSIRO for analysis and to report back to the industry and the individual classing facilities on their performance.

Before these samples are sent out to the various classing facilities, members of the CCAA visually class the samples according to the current USDA classing boxes.

## **3. Check Tests**

The weekly check test program involves forwarding two samples of cotton, collected at random by a classing facility from a bale or gin run, to other classing facilities for testing on the HVI lines that are operational during the ginning season. The main aim of the checktest is to determine the long term reproducibility of each HVI instrument. If an instrument was found to be out of tolerance the classing facility was notified and corrective action taken. In 2006 ten, seven in 2007 and in 2008 ten check test samples were sampled and tested according to CCAA procedures.

The reproducibility of the instruments was judged using the following tolerances as recommended by the CCAA; length +/- 0.02 inches, uniformity index +/- 1.0 %, micronaire +/- 0.1 units, strength +/- 2.0 gpt, Rd +/- 1.0 units and b+ +/- 0.6 units. These tolerances are similar to the ones used by the USDA.

#### **4. Audits**

The first audit took place in May 2005 and nine classing facilities were audited. This initial audit was considered to be a general or preliminary audit to determine standards within the classing sector, compliance to the draft BMP handbook and to highlight problematic areas that might require either a revision of the BMP handbook, or changes in classing practices. The second audit was more in depth and conducted in May 2006 with subsequent audits conducted on an annual basis.

#### **Results**

4. Detail and discuss the results for each objective including the statistical analysis of results.

##### **1. Module Averaging**

The results showed that module averaging systems do compensate for instrument variability and for the natural variability of cotton. It is further apparent that in all cases, with the exception of system C, the variability in results is reduced using System B over System A and the 100% tested bale values.

From this analysis it was recommend that system B be adopted as the module averaging system to be used in Australia. The reasons are as follows:

- The results for cotton with various quality characteristics show that system B has less variability then system A.
- The majority of classing facilities are already using system B which will make the adoption of this system by the Australian industry easier.

It was further recommended, that as is the case with the USDA, that module averages be assigned to outlier bales, outlier values defined as per Table 2, unless such bales were the first or last bale of the module or when the number of outlier bales in a module exceeds twenty percent of the total number of bales tested.

First and last bales of the module that have values measuring outside the permitted range (and bales outside the range when there is more than 20% of the total number of bales tested in the module) should be reported as outliers and should not be used in determining the module average. Outlier bales are assigned their own individual instrument readings. As a guideline the table below shows the range of measurements that are allowed by the USDA taking into account instrument variability and the natural variability of the cotton fibre.

**Table 2 Permitted Outlier Range**

<b>Measurement</b>	<b>Permitted Range</b>
Length	0.04 inches
Strength	3.0 g/tex
Micronaire	0.3 units
Length Uniformity	2.0 %

## ***2. Colour Round Trials***

Two Round Trials were conducted in 2004, which entailed the testing of 250 and 200 samples respectively on the HVI lines that were operational at that time (19 and 15 HVI lines respectively).

One Round Trial was conducted in 2006, 2007 and 2008 and entailed the testing of forty different samples representing a wide range of grades on the HVI lines that were operational at that time (14, 12 and 7 HVI lines respectively).

Each sample was tested as per the recommended CCAA procedure to ensure consistency of colour measurement on all instruments.

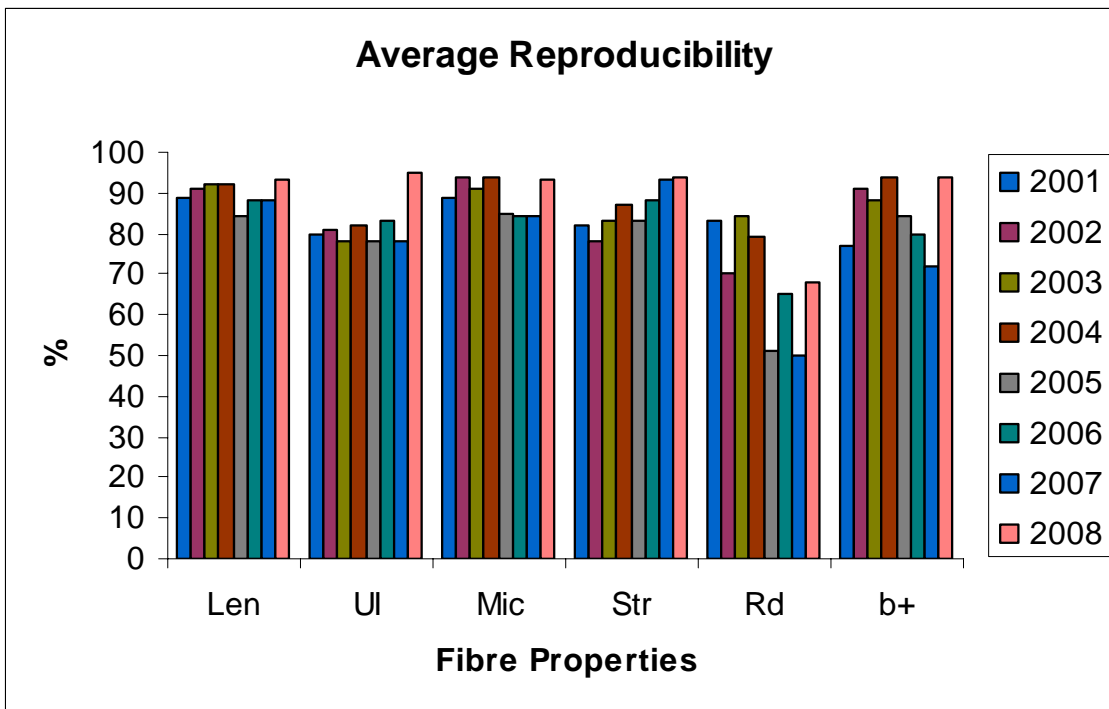
These trials found that while there were no significant differences in colour results over a range of different HVI lines located in one classing facility, but that there were significant differences, mainly in Reflectance(Rd) values between the same model of HVI lines located at different classing facilities.

A further Round Trial was conducted in 2008 where a set of calibration tiles were forwarded to the various classing facilities with 10 cotton samples representing a wide range of cotton grades. The facilities were required to calibrate their HVI lines with these tiles and then test the cotton.

These trials found that there were no significant differences in colour results between the different HVI lines. This was very encouraging and further trials will be carried out to verify these results.

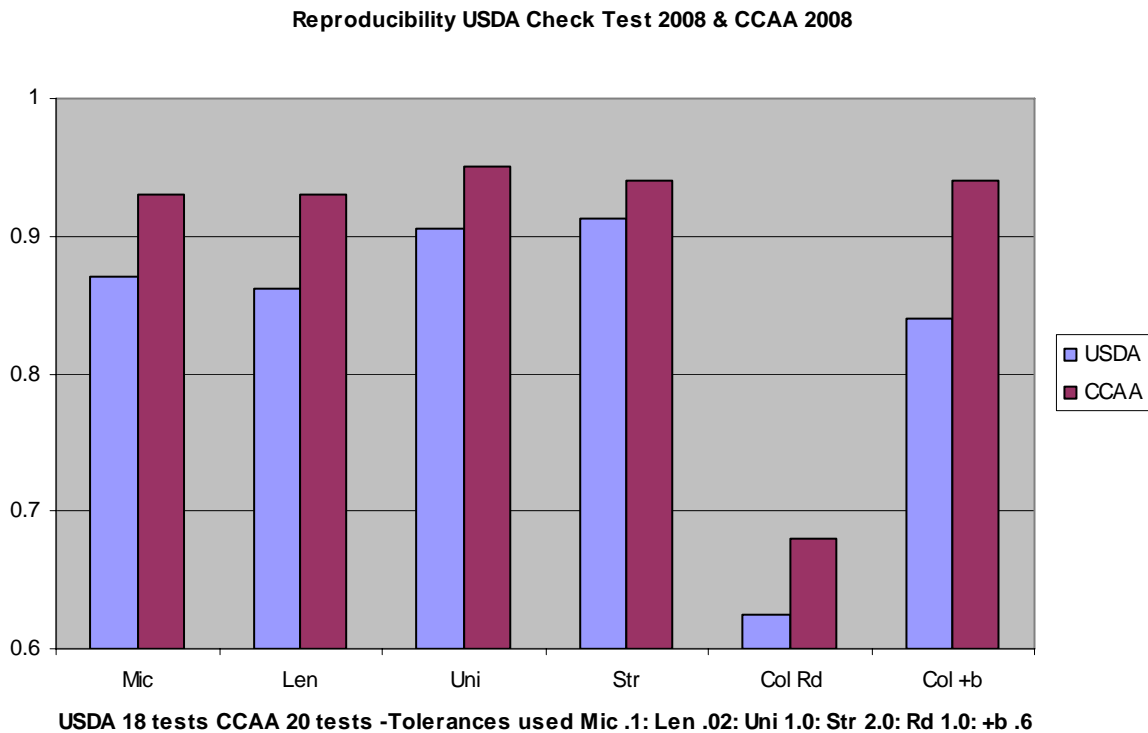
## ***3. Check tests***

With the exception of colour (as represented by Rd & b+) the reproducibility results for the four years from the 2005 to 2008 crop continue the trends of the 2001 to 2004 crop years (that were collated by the CCAA). Average values for micronaire, length, length uniformity and strength fall within the set tolerances with the average results for colour especially the Rd value being somewhat more variable. Feedback is given to the classing facilities and the research organisation that participate in these check tests on a weekly basis on the performance of their individual instruments. The results for 2008 are very encouraging with the reproducibility results for the six properties all improving from 2005. (See Figure 1)



**Figure 1 Average Reproducibility Results for six fibre properties as tested by HVI lines**

When comparing the reproducibility results achieved for the Australian HVI instruments in 2008 to the USDA check test program (which is a world wide check test program and includes around 60 to 70 HVI instruments) for 2008 it shows that the reproducibility of the Australian HVI instruments are better than the instruments that participate in the USDA check test.



**Figure 2 Comparison of reproducibility of Australian HVI instruments to USDA reproducibility results for 2008**

### ***Subjective classing compared to Objective classing***

Comparison of subjective classing, as determined by classers using USDA classing boxes and HVI objective measurements, show that there is a difference between the objective and subjective measurements with the HVI lines in most instances recording a lower or worse (i.e. 31 compared to 21) classing grade (CG) when compared to the CG recorded by the classers.

### ***International Collaboration***

The International Cotton Advisory Committee (ICAC) established a task force in December 2003 on the Commercial Standardisation of Instrument Testing of Cotton (CSITC) which has the objective of facilitating widespread use of instrument testing systems for Upland cotton varieties at the producer level while upholding the standards and tolerances that maintain the integrity of high-quality testing. CSITC is supported by the International Textile Manufacturers Federation (ITMF), the International Cotton Association (ICA), and major trading countries including Australia. The Task force is facilitating the adoption of instrument testing standards and procedures utilized by the United States Department of Agriculture (USDA) by all classing facilities around the world, and to introduce the use of instrument testing language in the trading of cotton so that traditional descriptions of grade or type are replaced with instrument test values.

The Task Force identified seven areas to encourage worldwide classification of cotton with standardised instrument testing methods and procedures. These include;

- 1) Definition of specifications for cotton trading based on HVI testing;
- 2) Definition of international test rules,
- 3) Implementation of test rules,
- 4) Certification of testing facilities,
- 5) Definition and provision of calibration standards,
- 6) Specification of commercial control limits for trading

The agreed commercial control limits are:

- Strength - +/-1.5(grams/tex)
  - Upper Half Mean Length (UHML) - +/- 0.02
  - Length Uniformity (UI) – +/- 1.0
  - Micronaire - +/- 0.1
  - Colour (Reflectance)Rd - +/- 1.5
  - Colour (Yellowness) +b - +/- 0.5
- 7) Establishment of arbitration procedures.

The CSITC agreed that the world cotton industry should not seek to establish an international classing facility, but that current and future classing facilities should be rated according to their performance relative to other participating classing facilities in CSITC Round Trials. Following two pilot round trials conducted in 2005 & 2006 the CSITC will hold four Round trials a year from 2007 onwards. Five cotton samples (Upland cotton) with known values are tested by each testing facility six times each day for five days, for the six properties mentioned earlier. Results for all

the tests are collected by the USDA and evaluated by the Bremen Fibre Institute. Laboratories are given an overall ranking (combining all fibre properties to indicate the level of performance in comparison to all other classing facilities) and also a ranking of their performance for each of the six fibre properties. These rankings are based on how close the mean value of each testing facility and instrument are to the grand mean value of all the participating testing facilities. A detailed explanation of the ranking method employed has been forwarded to the individual testing facilities that participated in the CSITC Round Trials. Further information can be found at <http://www.icac.org/>

The overall ranking from all HVI instruments (ranging from 69 to 85 instruments worldwide) for the last five Round Trials is shown in Table 1. One will note that the average values (the lower the average the better) for the overall ranking and all other fibre properties with the exception of b+ have remained fairly constant over the last 6 Round Trials conducted in 2007 and 2008.

**Table 1 – Overall ranking for all instruments in Round Trials**

	Average for 2007 - 2	Average for 2007 - 3	Average for 2007 - 4	Average for 2008 - 1	Average for 2008 - 2	Average for 2008 - 3
Overall	0.57	0.57	0.58	0.57	0.59	0.60
Micronaire	0.75	0.62	0.65	0.50	0.57	0.60
Strength	0.61	0.63	0.59	0.64	0.64	0.58
Length	0.47	0.53	0.49	0.61	0.51	0.58
Uniformity	0.40	0.41	0.45	0.46	0.58	0.48
Rd	0.54	0.61	0.62	0.58	0.53	0.58
b+	0.60	0.61	0.70	0.63	0.58	0.71
Facilities	54	54	58	518	63	60
HVI's	74	69	79	72	85	81

Four classing facilities in Australia with 6 HVI instruments participate in the CSITC Round Trials.

Australia is the only country that receives feedback on the results from the individual classing facilities/instruments that participate in these Round Trials. Results show that a number of Australian instruments are ranked in the top 20 for accuracy in a number of fibre properties and it is pleasing to note that the majority of instruments consistently record values below (i.e. better) than the world wide average rankings.

Although there is a cost involved in participating in these CSITC Round Trials classing facilities are encouraged to participate in these Round Trials as together with the CCAA Round Trials and Check Test program, they confirm the classing facility's ability to provide reproducible results. This is important in ensuring that Australian cotton is specified accurately and consistently to established international standards.

#### **4. Audits**

The BMP handbook for Classing has been amended on a regular basis and was last updated in February 2008. (Version 8.0)

All members of the CCAA that have classing facilities are audited, without prior notification, on an annual basis to determine their compliance to the current version of the BMP handbook. Following the audit, the auditor forwards an audit report to Cotton Australia which issues the classing facilities with their BMP certification.

Following the audits in 2006, six classing facilities were certified, in 2007 the same six classing facilities were certified, with two classing facilities receiving a non-compliance notification and in 2008 five were certified, with one classing facility receiving a non compliance notification.

#### **Outcomes**

5. Describe how the project's outputs will contribute to the planned outcomes identified in the project application. Describe the planned outcomes achieved to date.
  - The CCAA have accepted the recommendations made and from the 2006 crop onwards all the classing facilities are using a single Module Averaging system.
  - The Classing facilities are audited on an annual basis to determine their compliance to the current version of the BMP handbook for classing, which is constantly updated. All the commercial classing facilities in Australia, with the exception of one which is not a member of the CCAA, have been certified by Cotton Australia since 2006. This verifies that all the classing facilities are using the same practices and procedures to ensure accurate and reliable data. The BMP handbook has been given to the USDA and Uster Technologies (the major supplier of HVI lines) for comments/suggestions and the feedback from them has been very favourable.
  - The Reproducibility results for the weekly and international check tests show that from a technical view point the testing of cotton, objectively by HVI instruments for all fibre properties with the exception of colour, mainly Rd, is improving. Further work will be conducted on this aspect in the follow up project.
  - The Round Trials have given valuable feedback regarding the differences between classing facilities and HVI instrument models. The various classing facilities have upgraded and changed their procedures and practices to obtain more accurate, reliable and repeatable results.
6. Please describe any:-
  - a) technical advances achieved (eg commercially significant developments, patents applied for or granted licenses, etc.);
  - b) other information developed from research (eg discoveries in methodology, equipment design, etc.); and

c) required changes to the Intellectual Property register.

N/A

### *Conclusion*

7. Provide an assessment of the likely impact of the results and conclusions of the research project for the cotton industry. What are the take home messages?

In order for the Australian industry to remain a cotton producer of choice it needed to be able to describe and classify its product with accuracy and consistency. Over the past three years the CCAA and its members have endeavoured to standardise classing facilities so that they give reliable, consistent and repeatable results. This has entailed a number of programs, which have been independently assessed by CSIRO. They include; check tests both locally and internationally, round trials and the drawing up of Best Management Practices for classing and auditing of the facilities to determine compliance to the BMP. At huge costs a number of classing facilities went as far as replacing their older, problematic HVI lines with modern instruments. Australia is seen as an important member of the CSITC with delegates from Australia attending committee meetings and Australia is the only country in the world that analyses the results from CSITC round trials as an industry.

Results from these various programs have shown that the classing sector is moving forward but that the objective measurement of colour is still an issue. In the follow up project, with the assistance of Uster Technologies, the major supplier of HVI lines, a colour chart for Australian cotton will be drawn up to replace the current colour chart reflects US cotton which is creamier than Australian cotton.

### *Extension Opportunities*

8. Detail a plan for the activities or other steps that may be taken:
- (a) to further develop or to exploit the project technology.
  - (b) for the future presentation and dissemination of the project outcomes.
  - (c) for future research.

Feedback on programs is continuously given to participating classing facilities. Presentations are given to the CCAA at pre and post season meetings and also to the Australian Cotton Shippers Association.

### *Publications*

9. A. List the publications arising from the research project and/or a publication plan.

(NB: Where possible, please provide a copy of any publication/s)

N/A

## ***Part 4 – Final Report Executive Summary***

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Provide a one page Summary of your research that is not commercial in confidence, and that can be published on the World Wide Web. Explain the main outcomes of the research and provide contact details for more information. It is important that the Executive Summary highlights concisely the key outputs from the project and, when they are adopted, what this will mean to the cotton industry.

There is consensus both locally that the assessment of colour and trash by traditional subjective methods should be replaced with measurements by instruments in HVI lines. The basis of this consensus is recognition that classing grade is an important factor in defining the market price for a cotton and that the industry needs to achieve better accuracy and consistency in classing cotton to reduce risk along the fibre to fabric processing chain. There is however a number of technical and operating issues to overcome before objective measurement of these parameters are accepted with confidence by the cotton trade.

If Australia is to maintain its reputation as a consistent supplier of high quality cotton it will need to ensure that classing facilities in Australia consistently specify their cotton. To do this the cotton classing sector will need to be assessed independently via rigorous and formal round-robin trials, check tests colour trials and be audited so that individual facilities can make technical and operational corrections to their HVI practice and so that ultimately the industry can work towards better prediction of classing grade by HVI measurement. ACSA have requested that the subjective measurement of colour be discontinued and replaced by the objective measurement of colour by HVI. The follow up project, with the assistance of Uster Technologies, the major supplier of HVI lines, will focus on drawing up a colour chart for Australian cotton to replace the current colour chart as it reflects US cotton which is creamier than Australian cotton.